Canadian Centre for Occupational Health and Safety

Centre canadien d'hygiène et de sécurité au travail

EFFECTS OF MICROWAVES ON THE EYE

P89 - 15E

89-04670/

EFFECTS OF MICROWAVES ON THE EYE

Physical Hazards Group

Canadian Centre for Occupational Health and Safety

June 1989

CCOHS/CCHST

EFFECTS OF MICROWAVES ON THE EYE

Each publication produced by CCOHS undergoes several stages of review. As a part of this review, representatives from government, employers, and labour are requested to comment on draft copies of CCOHS documents for technical accuracy and readability.

Although every effort is made to ensure accuracy and completeness of the information, it is understood that CCOHS makes no warranty as to the accuracy or completeness of such information and assumes no liability for any damages or loss suffered as a result of any inaccuracy or incompleteness therein.

In the interest of the widest possible dissemination of occupational health and safety information, CCOHS invites users to copy and distribute its publications. Appropriate written acknowledgment is requested and appreciated. CCOHS asks that users report the number of publications so distributed--please notify the Inquiries Service. Users may wish to contact CCOHS to request paper or electronic master copies for reproduction.

Cette publication est offerte en français sous le titre : Les effets des microondes sur les yeux.

CCOHS NUMBER P89-15E
ISBN 0-660-13247-8
DSS CATALOGUE NUMBER CC273-2/89-15E

Published 1989

---

250 Main Street East
Hamilton Ontario
L8N 1H6
416-572-2981
FAX 416-572-2206
Telex 061-8532

CCOHS/CCHST

TABLE OF CONTENTS

1.	INTRODUCTION	1
2.	STRUCTURE OF THE EYE	2
3.	HOW MICROWAVES AFFECT THE EYE	3
	Animal Studies	3
	Human Studies	4
4.	MICROWAVE EXPOSURE LIMITS	4
5.	SUMMARY	5
	FURTHER READING	6

CCOHS/CCHST

1. INTRODUCTION

Microwaves are part of the electromagnetic spectrum. Microwaves fall in the frequency range from 300 MHz (megahertz) to 300 GHz (gigahertz). Microwaves are used for communication and for many different industrial purposes. Table 1 gives some examples of industrial uses of microwave devices in Canada.

Table 1 - Applications of microwaves in Canada

Industry	Process
Mining and Metallurgy	Desulphurizing coal
Metal Fabrication	Processing foundry cores Drying casting molds Drying pastes and washes Slip casting
Chemicals	Preheating and vulcanizing rubber Processing polymers Devulcanizing rubber
Wood and Paper	Curing wood composites Drying paper
Food and Beverage	Drying foods, such as pasta, noodles, biscuits, onions Cooking meat and other food products Vacuum drying Baking and proofing Sterilizing Freeze drying
Clothing and Textiles	Dye fixation Drying yarns and leather
Telecommunications	Transmission of information (for example, television, telephone)
Health Care	Therapeutic heating of tissue (diathermy)
Defense	Finding location, measuring distance (RADAR)

CCOHS·CCHST

The absorption of microwaves in the body affects various organs, primarily by changing the energy into heat. The eye is especially vulnerable to microwaves because it cannot properly dissipate the heat. This publication describes only the effects of microwaves on the eye. Other parts of the body, such as the central nervous system and the testes, are also sensitive to the effects of microwaves. For more information about the electromagnetic frequency spectrum and the possible biological effects of electromagnetic fields, contact CCOHS.

2. STRUCTURE OF THE EYE

For the sensation of sight, light must pass through several parts of the eye and focus on the retina. In order, these parts are the cornea, the aqueous humour, the crystalline lens and the vitreous humour (see the following figure).

The clarity of the image on the retina depends on the clarity of these parts. The crystalline lens focusses the image. Because they have to be transparent, the cornea, the lens and the gel-like vitreous humour do not contain blood vessels. On the other hand, the retina has many blood vessels. The retina's light receptors transform light into nerve impulses. The optic nerve sends these impulses to the brain.

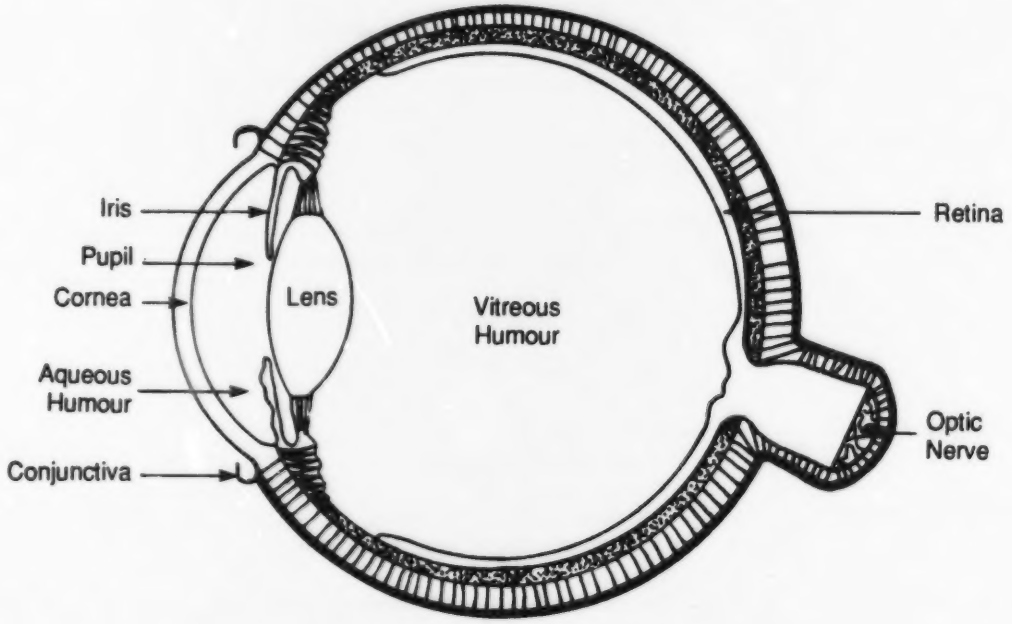

Figure - Horizontal section of an eye

3. HOW MICROWAVES AFFECT THE EYE

Heat is the major cause of eye damage from intense microwave exposure. At weak microwave exposures, the resulting heat can be dissipated without heating the eye's tissues.

Eye tissues with high water content, such as the vitreous humour, absorb more microwave energy than those with lower water content. The cornea, the lens and the vitreous humour do not have blood vessels. As a result they lack a direct blood supply that could carry away the absorbed microwave heat. Consequently, microwave "hot spots" form in the eye, which may result in tissue damage.

Animal Studies

The evidence of microwave-induced eye damage comes from animal experiments. Information on human exposure is limited.

Lens

The lens of the eye is always growing. As long as this growth proceeds normally, the lens remains transparent. Aging, drugs and diabetes can interfere with this growth. Areas of the lens become cloudy and develop cataracts.

In experimental animals, researchers have used high-intensity microwaves to induce cataracts. They found that cataracts from heat damage depend on the amount of energy absorbed. For single exposures for a duration of over one hour, the intensity of microwaves required to produce cataracts is above 100 mW/cm^2. The higher the intensity, the shorter the time required. There does not appear to be a cumulative effect from multiple microwave exposures, unless each single exposure is sufficient to produce some irreparable eye damage. Some of these results are controversial. Research is continuing in this area.

The potential of microwaves to produce cataracts varies with frequency. The most damaging frequencies are in the range between 1 and 10 GHz.

Studies showed that under some conditions, cataract development also depends on the way that the microwave amplitude varies with time. Pulsed microwaves seem to be more dangerous than non-pulsed or continuous-wave microwaves.

They also demonstrated that microwaves increase the cataract-causing effects of some chemicals, such as alloxan and galactose. Microwave exposure can also speed up the formation of cataracts caused by diabetes.

Cornea

The thin, inner layer of the cornea, the endothelium, is important in maintaining the transparency of the cornea. Any serious damage to the endothelium can cloud the cornea and distort vision. Microwaves can damage the cornea's endothelium. The combination of microwaves and drugs that treat glaucoma, such as pilocarpine and timolol maleate, is particularly damaging to the cornea's endothelium.

Retina

The retina is the most complex of the eye's tissues. It is a direct outgrowth of the central nervous system. Researchers have found that microwaves can damage the nerve endings of the retina in animals.

Other Effects

Intense microwaves cause the glands around the eye to tear and become inflamed. It also causes burning and swelling of the eyelid and the membrane (conjunctiva) that lines the inner surface of the eyelids and the forepart of the eyeball. Such exposure also causes inflammation of the iris, constriction of the pupil and damage to the vitreous humour.

Human Studies

Researchers have done several surveys to determine whether human exposure to microwaves could cause cataracts. Some studies of people exposed to microwaves have found a slight but statistically significant increase in cataracts. Other studies have found no effect.

The effect of long-term, low-intensity microwaves on the human lens is poorly understood. Several studies suggest that occupational microwave exposure is involved in increasing lens aging and injury to the retina. The exact cause of the injuries remains unknown.

4. MICROWAVE EXPOSURE LIMITS

Health and Welfare Canada recommends limits for microwave exposure in its publication "Safety Code-6," which Table 2 summarizes. These recommendations are currently under review. The need for personal protective equipment may arise in specialized high-intensity microwave applications.

In Canada there are no regulations requiring eye examinations for those occupationally exposed to microwaves.

Table 2 - Canadian Safety Code-6 occupational microwave exposure limits

Frequency Range	Measured Field*	Exposure Limit Averaged Over 1 hour	1 minute
10 MHz-1 GHz	E	60 V/m	300 V/m
	H	0.16 A/m	0.8 A/m
	P	1 mW/cm^2	25 mW/cm^2
1 GHz-300 GHz	E	140 V/m	300 V/m
	H	0.36 A/m	0.8 A/m
	P	5 mW/cm^2	25 mW/cm^2

* E = Electric field (in volts per meter)
H = Magnetic field (in amperes per meter)
P = Power density (in milliwatts per square centimeter)

5. SUMMARY

Exposure to microwaves intense enough to raise the temperature of the eye parts can cause damage, including burns and swelling of the eyelids and conjunctiva. Microwaves can produce cataracts if exposure is of sufficient intensity and duration. The most damaging microwaves are between 1 and 10 GHz.

Microwaves increase the ability of certain chemicals to cause cataracts. They can also increase the susceptibility of cataracts from diabetes.

If microwave exposures to workers are kept below the current exposure limits, no further precautions are required.

CCOHS CCHST

FURTHER READING

Aurell, E. et al. Lenticular and retinal changes secondary to microwave exposure. Acta Ophthalmologica. Vol. 51 (1973) p. 764-771.

Cleary, S.F. Microwave cataractogenesis. Proceedings of the IEEE. Vol. 68, no. 1 (1980) p. 49-55.

Cleary, S.F. et al. Lenticular changes in microwave workers: a statistical study. Archives of Environmental Health. Vol. 12 (1966) p. 23-29.

Creighton, M.O. et al. In vitro studies of microwave-induced cataract. II, Comparison of damage observed for continuous wave and pulsed microwaves. Experimental Eye Research. Vol. 45, no. 3 (1987) p. 357-373.

Kues, H.A. et al. Effects of 2.45 GHz microwaves on primate corneal endothelium. Bioelectromagnetics. Vol. 6, no. 2 (1985) p. 177-188.

Michaelson, S.M. et al. Biological effects and health implications of radiofrequency radiation. New York: Plenum Press, 1987. p. 559-602.

Paulsson, L.-E. et al. Retinal damage experimentally induced by microwave radiation at 55 mW/cm^2. Acta Ophthalmologica. Vol. 57 (1979) p. 183-197.

Recommended safety procedures for the installation and use of radiofrequency and microwave devices in the frequency range 10 MHz-300 GHz. (Safety code 6) Ottawa: Health and Welfare Canada, 1979.

Stewart-DeHaan, P.J. et al. In vitro studies of microwave-induced cataract: separation of field and heating effects. Experimental Eye Research. Vol. 36 (1983) p. 75-90.

Stewart-DeHaan, P.J. et al. In vitro studies of microwave-induced cataract: reciprocity between exposure duration and dose rate for pulsed microwaves. Experimental Eye Research. Vol. 40 (1985) p. 1-13.

Stuchly, M.A. Proposed revision of the Canadian recommendations on radiofrequency-exposure protection. Health Physics. Vol. 53, no. 6 (1987) p. 649-665.

Tengroth, B. Hazardous effects on the eye of radiofrequencies and microwaves. Giornali Italiano di Medicina del Lavoro. Vol. 4, no. 1 (1982) p. 17-19.

Zaret, M.M. Selected cases of microwave cataract in man associated with concomitant annotated pathologies. In: International Symposium on Biologic Effects and Health Hazards of Microwave Radiation. Bethesda, Md.: National Institute for Occupational Safety and Health, 1974. p. 294-301.

READER'S NOTES

CCOHS·CCHST